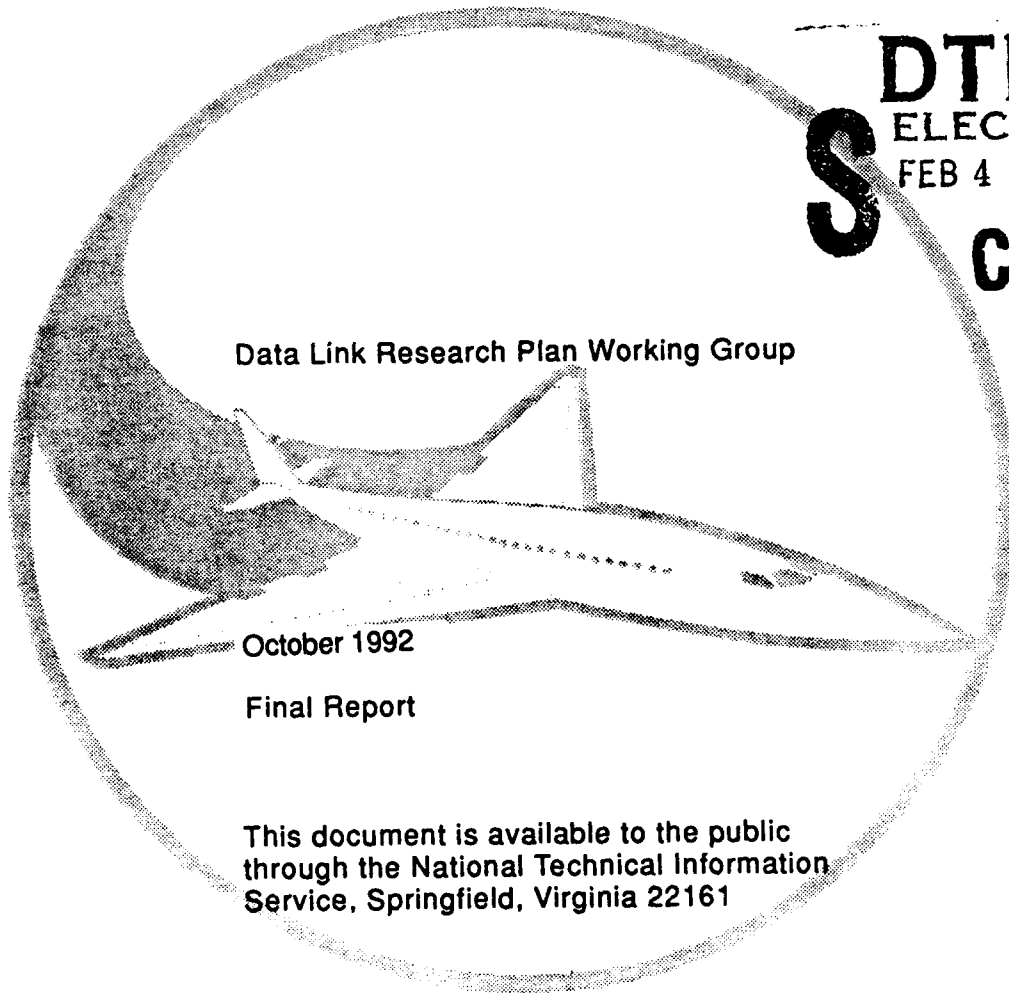AD-A260 010

||||||||||||||||||||

DOT/FAA/CT-92/23

FAA Technical Center
Atlantic City International Airport
N.J. 08405

FAA Technical Center Aeronautical Data Link Research Plan

Data Link Research Plan Working Group

October 1992

Final Report

This document is available to the public through the National Technical Information Service, Springfield, Virginia 22161

U.S. Department of Transportation
Federal Aviation Administration

93-01879
||||||||||||||||||||

93   2 1   00

NOTICE

This document is disseminated under the sponsorship
of the U.S. Department of Transportation in the interest of
information exchange. The United States Government
assumes no liability for the contents or use thereof.

The United States Government does not endorse
products or manufacturers. Trade or manufacturers'
names appear herein solely because they are considered
essential to the objective of this report.

1. Report No. DOT/FAA/CT-92/23	2. Government Accession No.	3. Recipient's Catalog No.

4. Title and Subtitle FAA TECHNICAL CENTER AERONAUTICAL DATA LINK RESEARCH PLAN		5. Report Date October 1992
		6. Performing Organization Code ACD-320
7. Author's) Data Link Research Plan Working Group		8. Performing Organization Report No. DOT/FAA/CT-92/23
9. Performing Organization Name and Address Department of Transportation Federal Aviation Administration Technical Center Research Directorate for Aviation Technology Atlantic City International Airport, N.J. 08405		10. Work Unit No. (TRAIS)
		11. Contract or Grant No. F2205A
12. Sponsoring Agency Name and Address Department of Transportation Federal Aviation Administration 800 Independence Avenue, S.W. Washington, D.C. 20591		13. Type of Report and Period Covered Final Report October 1991 to September 1992
		14. Sponsoring Agency Code ARD-200

15. Supplementary Notes

Questions regarding this report may be referred to Ephraim Shochet, ACD-320.

16. Abstract

The purpose of this plan is to project a clear and distinct description of the Data Link research that is to be conducted at the Federal Aviation Administration (FAA) Technical Center over the next 4 years. It explicityly defines what is to be achieved at a specific time in the future. End-to-end, high fidelity simulations will be the primary methodology for answering research questions. The end-to-end simulations identified in this plan are intended to investigate controller/aircrew integration issues using candidate Data Link hardware and software configurations. Research will also focus on testing Data Link applications in terms of their impact on controllers, aircrew, and the overall safety, efficiency, and productivity of the system. Additionally, research efforts are planned to address the most critical human factors issues surrounding Data Link.

The following people contributed to this report: Barbara Cassada, George Chandler, Evan Darby, Thomas Pagano, Albert Rehmann, Ephraim Shochet, Nicholas Talotta, John Van Dongen, ACD-320.

17. Key Words Data Link Research Plan	18. Distribution Statement This document is available to the U.S. public through the National Technical Information Service, Springfield, Va. 22161		
19. Security Classif. (of this report) Unclassified	20. Security Classif. (of this page) Unclassified	21. No. of Pages 62	22. Price

Form DOT F 1700.7 (8-72)   Reproduction of completed page authorized

ACKNOWLEDGEMENTS

TABLE OF CONTENTS

LIST OF ILLUSTRATIONS

LIST OF TABLES

EXECUTIVE SUMMARY

The purpose of this plan is to project a clear and distinct description of the Data Link research that is to be conducted at the Federal Aviation Administration (FAA) Technical Center over the next 4 years. It explicitly defines what is to be achieved at a specific time in the future.

The overall goals of Data Link development efforts at the FAA Technical Center are to produce an air-ground digital communications system that will (1) effectively relieve voice-radio frequency congestion, (2) maintain or enhance the safety, efficiency, and capacity of the air traffic control (ATC) system, (3) provide useful new services to National Airspace System (NAS) users, and (4) support the introduction of advanced ATC automation by creating a channel for direct dialogue between ground-based and airborne computer systems.

This plan distinctly recognizes the needs of the user communities and is, therefore, in complete accord with the research requirements identified by the Radio Technical Commission for Aeronautics (RTCA) 169 Working Group, the Air Transport Association (ATA), and the Society of Automotive Engineers (SAE) G-10 subcommittee, etc. Data Link customers include both the Air Traffic Division of FAA which defines ATC requirements and aircraft operators who use ATC services. In many ways, the goals of these two groups are similar. Both are interested in safe and efficient aircraft operations. However, their priorities for implementing Data Link services may differ. In any case, research efforts must be aimed at resolving issues of primary concern to both groups and at developing services that are deemed beneficial to both groups.

A "snapshot picture" of the research plan can be seen by examining figures E-1, E-2, and E-3. Figure E-1 describes the simulation schedule and identifies the research issues for evaluating Data Link in the En Route environment. Similarly, figures E-2 and E-3 specify the simulation schedule and the research issues for the Terminal and Interfacility environments, respectively. The interfacility testing will involve concurrent simulation of adjacent En Route and Terminal air spaces.

End-to-end, high fidelity simulations will be the primary methodology for answering research questions. The end-to-end simulations identified in this plan are intended to investigate controller/aircrew integration issues using candidate Data Link hardware and software configurations. For these simulations, the Data Link test bed will be connected to flight simulators including those at the FAA Technical Center, NASA-Ames, Boeing Corporation, AVIA, Inc., and other sites yet to be determined. The flight simulators will be staffed by airline pilots trained in Data Link communications. Through the assessment of their performance based on objective measures and their subjective insights on operational

FY 93 FY 94 FY 95 FY 96

HOST/PVD

HOST/ISSS PROTOTYPE

HOST/ISSS BUILD

RESEARCH ISSUES

E1 E2 E3 E3 E4 E5 E6 E7 E8

CONTROLLER INTERFACE DESIGN EVALUATION

ADL EFFECTS ON CONTROLLER/PILOT PERFORMANCE

EFFECT OF DISSIMILAR ADL DISPLAYS ON OPERATIONAL EFFICIENCY AND SAFETY

ENHANCED ADL SERVICE EVALUATION

FLIGHT MANAGEMENT SYSTEM INTEGRATION EVALUATION

METERING AND SPACING TOOL EVALUATION

PRODUCTION HOST/ISSS EXPANDED SERVICE EVALUATION

AREA CONTROL FACILITY IMPLEMENTATION EVALUATION

FIGURE E-1. EN ROUTE ENVIRONMENT ADL SIMULATION SCHEDULE
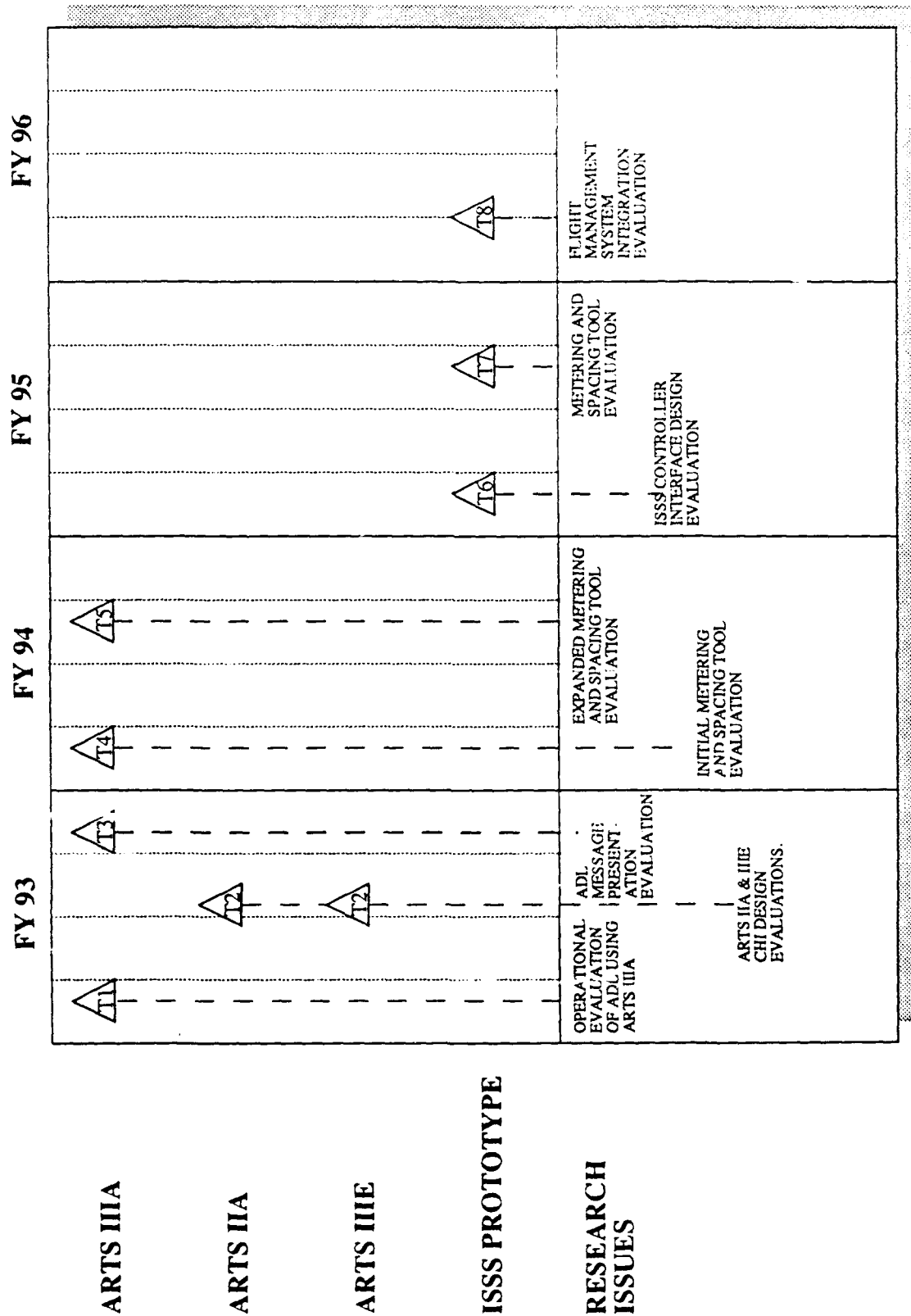
FIGURE E-2. TERMINAL ENVIRONMENT ADL SIMULATION SCHEDULE.
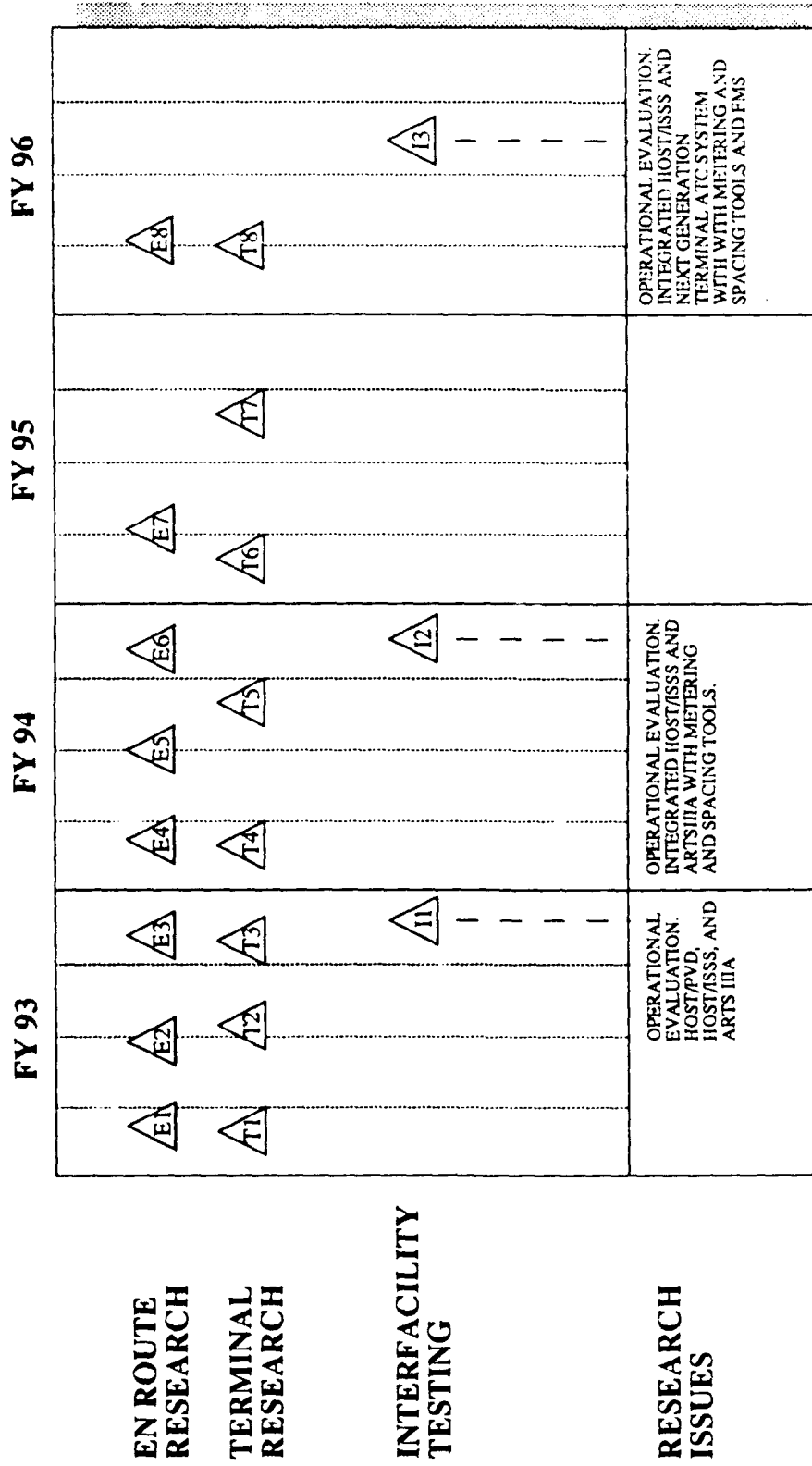
FIGURE E-3. INTERFACILITY ADL SIMULATION SCHEDULE

	FY 93	FY 94	FY 95	FY 96
EN ROUTE RESEARCH	E1 E2	E3 E4 E5 E6	E7	E8
TERMINAL RESEARCH	T1 T2	T3 T4 T5	T6 T7	T8
INTERFACILITY TESTING		I1 – – –	I2 – – – –	I3 – – – –
RESEARCH ISSUES	OPERATIONAL EVALUATION. HOST/PVD, HOST/ISSS, AND ARTS IIIA	OPERATIONAL EVALUATION. INTEGRATED HOST/ISSS AND ARTS IIIA WITH METERING AND SPACING TOOLS.		OPERATIONAL EVALUATION. INTEGRATED HOST/ISSS AND NEXT GENERATION TERMINAL ATC SYSTEM WITH WITH METERING AND SPACING TOOLS AND FMS

viability, conclusions will be formulated on Data Link system performance and user group acceptance. Research will also focus on testing Data Link applications in terms of their impact on controllers, aircrew, and the overall safety, efficiency, and productivity of the ATC system.

Additionally, research efforts are planned to address the most critical human factors issues surrounding Data Link. During the next 4 years, this research should accomplish the following major objectives:

1. Provide test designs, measures, and data to support design development studies of controller and pilot Data Link interfaces for high priority ATC services.

2. Produce data from high fidelity, manned simulation studies which quantify the hypothesized benefits of Data Link for ATC communications and overall system performance.

3. Conduct end-to-end controller/pilot in-the-loop simulation studies which isolate potential Data Link communication errors and define the limits of Data Link applicability (e.g., maximum delays, traffic levels, airspace sector types).

In summary, the present state of human factors knowledge and research capability at the FAA Technical Center has laid a solid foundation for future research that will be needed to take Data Link from the demonstration stage of development to a proven operational ATC communication system.

1. OBJECTIVE.

The Federal Aviation Administration (FAA) Technical Center Aeronautical Data Link (ADL) Research Plan establishes the planning baseline for research necessary to resolve the issues associated with integration of ground-based air traffic control (ATC) systems with their flight deck counterparts through the Data Link communications medium. This document provides the requirements framework about which individual detailed research plans will be developed.

This plan was initiated in recognition that the issues identified by both government and industry must be systematically explored and definitively resolved. It recognizes that, although some may be node specific (i.e., air or ground), all issues must be addressed in context of their impact on the total system. It also recognizes that the operational environment in which ADL communications are exercised will influence the utility of this medium and its operational effectiveness.

2. SCOPE.

This plan correlates ADL issues and postulates a time ordered set of experiments for their resolution. It reflects the implementation schedules of the prime equipments which depend upon the availability of ADL to fully exploit their capabilities. It recognizes the needs of the user communities as expressed by such organizations as the Radio Technical Commission for Aeronautics (RTCA), the Air Transport Association (ATA), and the Society of Automotive Engineers (SAE) (G-10 subcommittee). It draws upon the expertise of the FAA Technical Center staff who have successfully combined ADL service development and human factors research in many previous ADL experiments. It also exploits the proven test bed capabilities uniquely designed for ADL research that are resident at the FAA Technical Center.

Section 3 of this document provides a brief discussion of the background of ADL and the activities conducted to date by the FAA Technical Center concerning ground implementation of ADL. Activities of RTCA Special Committee (SC) 169 that relate to ADL ground implementation are also described. Research methodologies are described and discussed in section 4. FAA Technical Center system implementation and development schedules of prime systems that employ ADL capabilities are identified and discussed in section 5. Section 6 sets forth the set of experiments that will be conducted in the FAA Technical Center Data Link test bed to explore and resolve a variety of ADL issues. The genesis of the requirement, test objectives, test methodologies, and the expected results are presented for each experiment. Section 7 presents a partial discussion of research issues related to human factors and ADL development. Section 8 identifies open issues relating ADL implementation that are not included elsewhere in the plan.

1

Appendixes are included to amplify information contained in the body of the plan.

3. BACKGROUND.

The FAA's Capital Investment Plan (CIP) outlines a comprehensive program to modernize the National Airspace System (NAS) to meet anticipated growth demands. A major feature of the CIP is its dependence on advanced automation technology to produce a safer, more efficient NAS with measurable benefit to both NAS service users and NAS service providers.

To fully exploit the advantages of automated processes, the modernized NAS encourages digital exchange of critical information among and between ground and airborne computers. This capability is termed ADL. Extensive ADL use is essential to achieve the goals of enhanced safety, increased efficiency, higher productivity, and increased capacity.

Until recently, use of voice-radio equipment, procedures, and techniques were able to meet virtually all ATC communications requirements. However, the unprecedented growth in air traffic volume has clearly demonstrated the limitations of voice-radio communications and the need for complementary media to support operational demand.

ADL implementation offers the potential for significant near-term operational advantage to ATC specialists and aircrews through a reduction in radio frequency congestion and communication error. For the longer term, potential coupling of airborne and ground ATC computers through the ADL medium offers an even more robust set of operational advantages to both.

Initially, ADL will be used to exchange a limited set of ATC messages which replicate those transmitted via the voice channel. These messages, termed Initial ADL Services, include delivery of Pre-Departure Clearances (PDC), Transfer Of Communications (TOC), Initial Contact (IC), Terminal Information (TI), Heading, Speed, and Altitude instructions, and Automatic Terminal Information Service (ATIS).

In the longer term, capabilities will be expanded to accommodate more extensive information and instructions sets. It is intended for these to be provided in a form appropriate to the operational situation and suitable for computer processing by the airborne platform.

To implement ADL to its full potential, the issues associated with evolving from a voice-based to a mixed voice and ADL environment must be identified and resolved and the operational risks fully exposed and assessed. Efforts to this end have been initiated by

2

both industry and the FAA. Principle activities in this regard are described in the sections which immediately follow.

3.1   RTCA SC 169 WORKING GROUP (WG)-1 EFFORTS.

Although technologically possible, duplicating existing voice ATC messages in their entirety is neither operationally practical nor cost-effective from either ground or cockpit perspectives. It is apparent, however, that use of a subset of these messages, either singly or in combination, will offer operational advantage if tailored to suit the ADL medium and its users.

WG-1 of RTCA SC for ADL applications (SC-169) is chartered to define the set of ATC messages that are appropriate for exchange via the ADL medium. Initial efforts are documented in the RTCA SC-169 WG-1 paper of March 5, 1992, which presents a broad but invalidated sample of the potential utility of this emerging communications medium.

As shown in this paper, operational factors which influence the determination of the ADL message set are the ATC environment in which the aircraft is operating, the aircraft's phase of flight, and the type (or class) of message that will be exchanged. These are explained in appendixes A, B, and C, respectively.

3.2   ADL SERVICES SURVEY.

To obtain an early sense of aviation community opinion, a survey was conducted by the Collision Avoidance and Data Systems Branch (ACD-320) of the FAA Technical Center's Engineering, Research, and Development Service under the auspices of RTCA SC-169. The survey organized RTCA SC-169 WG-1 services in a fashion that would support review by members of RTCA SC-169 aviation community groups. These were: airline pilots, air traffic controllers, airlines, aircraft and avionics designers and manufacturers, and, ATC system designers and developers.

Individuals were requested to rate 40 Data Link services on the basis of the level of benefit that service implementation would have on aircrews, controllers, airlines, and the ATC system in general.

Findings and other survey details are contained in DOT/FAA/CT-ACD32092/3, A Survey of Data Link Air Traffic Services and Functions: Results Summary, dated May 7, 1992. Services with the highest perceived benefit across all communities have been extracted and are provided herein as appendix D. The survey results will be used in the prioritization of ADL service development.

3.3 GROUND ADL SIMULATION ACTIVITIES.

Understanding the effects of ADL use on the people, systems, and equipment used to control air traffic is an essential step in the development of the ADL communications capability. Among others, Service delivery methods including message content, format, display presentation characteristics, and transmission delay parameters must be assessed to establish development specifications. Similarly, Computer-Human-Interface (CHI) concerns must be investigated and related issues identified and resolved to enhance controller acceptance and to assure optimum controller performance. The effects of ADL implementation on NAS performance must also be quantified to ensure that air safety is not degraded and to assess air traffic capacity and efficiency.

To this end, the Air Traffic Data Link Validation Team (ATDLVT) and ACD-320 have conducted a series of studies and controlled experiments (termed Mini Study) using the FAA Technical Center Data Link test bed. These have been designed to evaluate sets of Initial Data Link services in the En Route and Terminal ATC environments.

3.3.1 EN ROUTE MINI STUDY 1.

The objectives of En Route Mini Study 1 were to:

   a. Evaluate and refine Data Link controller procedures and displays for the Altitude Confirmation, TOC, and En Route Minimum Safe Altitude Warning (EMSAW) Services.

   b. Solicit initial opinions from controllers regarding the general utility of the Mode S Data Link.

Findings and experiment details are contained in DOT/FAA/CT-88/25, Controller Evaluation of Initial Air Traffic Control Services: Mini Study 1, Volumes I and II, dated September 1988.

3.3.2 EN ROUTE MINI STUDY 2.

The objectives of En Route Mini Study 2 were to:

   a. Define applications and controller procedures for the added free text and menu text services.

   b. Evaluate the refined altitude assignment and transfer of communication services as well as the text services under more complex test conditions than those employed in Mini Study 1.

   c. Provide a preliminary assessment of Data Link time delays, system degradation, and partial Data Link equipage of controlled aircraft.

4

Findings and experiment details are contained in DOT/FAA/CT-89/14, Controller Evaluation of Initial Air Traffic Control Services: Mini Study 2, Volumes I and II, dated March 1989.

3.3.3 En Route Mini Study 3.

The objectives of En Route Mini Study 3 were:

   a.   ATDLVT evaluation of the Washington Air Route Traffic Control Center (ARTCC) airspace as implemented in the Data Link test bed.

   b.   ATDLVT evaluation of refinements to the Data Link service designs.

   c.   ATDLVT evaluation of preliminary communications backup downlink design.

   d.   Preliminary ATDLVT evaluation and determination of the NAS and Data Link functions the D-controller may perform.

   e.   Preliminary discussion of formal Data Link operational procedures.

   f.   Determination of how collected data can be used to help development of performance measures to be used in Data Link testing.

Findings and experiment details are contained in DOT/FAA/CT-91/11, Controller Evaluation of Initial Air Traffic Control Services: Mini Study 3, dated June 1991.

3.3.4 Investigation of Initial Data Link Terminal ATC Services.

The objectives of this, the first Terminal Data Link study, were to:

   a.   Determine the acceptability of the preliminary service designs.

   b.   Identify requirements for design modifications and enhancements.

   c.   Elicit controller estimates of the operational suitability, user acceptance, and workload impacts of TOC, IC, TI, and Menu Text (MT) services in the Terminal environment.

Findings and experiment details are contained in DOT/FAA/CT-90/29, Controller Evaluation of Initial Data Link Terminal Air Traffic Control Services, dated January 1991.

5

3.3.5 Terminal Mini Study 2.

The objectives of Terminal Mini Study 2 were to:

    a.   Evaluate the acceptability of enhanced designs for Initial Data Link Terminal services.

    b.   Resolve open Service design issues.

    c.   Provide a preliminary assessment of the impact of system delay/pilot response time on the usability and effectiveness of the initial terminal services.

    d.   Evaluate the effectiveness of a subject training protocol.

    e.   Evaluate the validity of experimental system and controller performance measures for use in future operational evaluation studies.

Findings and experiment details are described in the report, Controller Evaluation of Initial Data Link Terminal Air Traffic Control Services: Mini Study 2, DOT/FAA/CT-92/2, Volumes 1 and 2.

3.3.6 Terminal Mini Study 3.

The objectives of Terminal Mini Study 3 were to:

    a.   Conduct a usability evaluation of the modifications made to the Data Link CHI since Mini Study 2.

    b.   Determine the strategies controllers apply to use Data Link most effectively in the terminal environment.

    c.   Evaluate the effectiveness of objective performance measures as applied to simulation-based tests of Data Link.

Findings and experiment details are contained in the report Controller Evaluation of Initial Data Link Terminal Air Traffic Control Services: Mini Study 3, DOT/FAA/CT-92/18, which is currently in publication.

3.4 OPERATIONAL EVALUATION OF INITIAL EN ROUTE DATA LINK SERVICES.

An Operational Evaluation of the En Route Altitude Assignment, TOC, MT and Free Text (FT) ATC services was performed in a high fidelity simulation conducted in the Data Link test bed in late 1989. The objectives of this evaluation were to:

    a.   Measure the beneficial effect of Data Link on voice frequency congestion.

b. Determine the impact of Data Link on ATC performance and effectiveness, controller workload and controller acceptance.

Concurrently, a study was conducted to evaluate the overall effectiveness of Data Link communications in aircraft operations both for the uplinked ATC services and for a set of Data Link weather services available from simulated data bases. This study used the FAA Technical Center's General Aviation Trainer (GAT) and NASA Ames' Boeing 727 flight simulators. Both were "flown" by pilots qualified in type.

Findings and experiment details are contained in DOT/FAA/CT-90/1, Operational Evaluation of Initial Air Traffic Control Services, Volumes I and II, dated February 1990.

3.5 EN ROUTE DATA LINK FUNCTIONAL SPECIFICATION.

En Route Data Link service evaluation activities culminated in the development of a functional specification which defines the Host computer processing requirements for implementation of initial Data Link ATC services. This document (published as DOT/FAA/CT-91/12, Functional Baseline Specification for ATC Data Link Service Implementation in the Host Computer System, dated June 1991, addresses the use of Data Link services with current ATC procedures, controller inputs, and display outputs. In addition, requirements for supervisory functions and support software capabilities are identified therein.

4. RESEARCH METHODOLOGIES.

Evaluation of system designs and performance can be accomplished using many different methods, each intended for a specific purpose and each demanding a certain level of fidelity and sophistication. This section discusses the methods that will be used in evaluating ADL designs. In increasing order of fidelity, these are prototyping, part task simulation, end-to-end simulation, and operational demonstration.

As evidenced by the work discussed in section 3, the FAA Technical Center has evolved capabilities that employ each of these methods. As will be shown in section 6, these methods will be used in a coordinated fashion to evaluate and resolve ADL design and implementation issues.

A brief overview of the current FAA Technical Center ADL test bed is also included to provide the reader with a basic understanding of its capabilities.

4.1 PROTOTYPING.

Prototyping provides a cost effective, efficient method of evaluating human/system performance or advanced system designs. It is particularly suited to iterative design/test cycles.

To contain costs and reduce test development time requirements, prototypes of systems generally do not incorporate all of the capabilities found in the operational system. Typically, the prototype will feature a high quality representation of critical portions of the system with a lower quality or static representation of the less critical or secondary system aspects. Typically, a computer emulation of the operational hardware is developed on high-speed graphical computers. The computer display is programmed to model the planned display and functions of the system.

Prototyping is typically used in the evaluation of human/system interface design alternatives. The relative low cost and quick development time allows designers the freedom to investigate relative system performance between different system designs. For ATC evaluations, the computer would emulate the displays used by controllers. For flight deck evaluations, the computer would emulate the cockpit interfaces including the out-the-window view. The computers are programmed to provide responses to operator inputs that correspond to the responses provided by a planned operational system.

Prototyping will be used in the development of ADL services in an ongoing mode. The ATC ADL system interface as well as service implementations will be developed and tested using system prototypes. The ADL Development Program at the FAA Technical Center uses personal computer (PC) based prototypes for a first order evaluation of ADL designs.

Because the prototype development and investigations will be flexible in scheduling and reactive to previous findings, they are not identified in the test schedules presented in section 6. The findings of these prototype tests will be used in the development of the hardware and software used in higher fidelity part task and end-to-end simulations identified in section 6.

4.2 PART TASK SIMULATION.

Part task analysis isolates particular functions or portions of the system under test using either operational systems or systems which closely emulate the performance of operational systems. Many ADL issues can be explored using part task analysis techniques.

Part task simulation is particularly suited for evaluation of the performance of specific system functions and controller and pilot performance while using those functions. Such simulations provide

8

designers with a cost effective method to test system performance
during the design phase. Additionally, the technique provides a
cost effective method for controllers, pilots, government and
industry representatives, and other subject matter experts to
evaluate system designs prior to operational implementation. The
individual components of the ADL test bed, including the Automated
Radar Terminal System (ARTS), Host, and Initial Sector Suite
Systems (ISSS) Prototype Laboratories, provide the FAA Technical
Center with a unique facility for conduction part task simulations.

4.3   END-TO-END SIMULATION.

End-to-end simulations exercise the existing capabilities of the
system being evaluated. They are designed to emulate real-world
conditions at the highest level of fidelity possible within fiscal
and time constraints.

The end-to-end simulations identified in this plan are intended to
investigate controller/aircrew integration issues using candidate
ADL hardware and software configurations. The hardware and
software configurations used will be those proven through prototype
testing or those selected through part task simulations.

In addition to candidate ATC systems, ADL end-to-end simulations
will incorporate appropriately configured flight simulators. ADL
test bed laboratories will be electronically coupled to local and
remote flight simulators. These include those located at the FAA
Technical Center, NASA-Ames, Boeing Corporation, AVIA Incorporated,
and other sites as are suitable and available.

The term "end-to-end simulation" is often used to connotate two
types of simulations. Traditionally, simulations testing ground
to air communications/operations covering all phases of flight from
departure to arrival are termed end-to-end. Typically, flight
simulators will depart from an airport in the simulated environment
and land in a different airport within the simulated environment.
The simulated aircraft will traverse terminal and en route airspace
during this type of simulation. The traditional end-to-end
simulations recommended in this plan are presented in the
interfacility portion of section 6.3.

A second type of end-to-end simulation involves ground to air
communications/operations but is isolated to one air traffic
environment. The simulations identified as terminal or en route
end-to-end simulations will be of this type. These simulations
are presented in sections 6.1 and 6.2.

4.4   OPERATIONAL EVALUATION.

Operational evaluations are intended as proof of concept of the
final hardware and software designs. Operational evaluations
enable user groups and system designers to evaluate the operational

software and hardware before the initial fielding of the system. Such activities are conducted in a rigorously controlled operational setting that replicates real-world conditions at the highest level of fidelity possible within fiscal and time constraints.

ADL operational evaluations will again couple the ATC software and hardware contained in the ADL test bed with appropriately equipped local and remote flight simulators. If practical, airborne ADL equipped aircraft will be included. To the extent possible, the capabilities of the Aeronautical Telecommunications Network (ATN) will be used as the ADL communications medium.

4.5 ADL TEST BED COMPONENTS.

The FAA Technical Center ADL test bed (see figure 1) comprises the NAS En Route Laboratory, several Terminal Laboratories, the Target Generation Facility (TGF), the FAA Technical Center Human Factors Laboratory, and the ADL Laboratory.

4.5.1 NAS En Route Laboratory.

The NAS En Route Laboratory emulates a generic ARTCC. Included are an operational Host system with controller displays and operational communications systems. The laboratory can be configured to represent en route airspace characteristics suited to experimental objectives. The NAS En Route Laboratory will also incorporate operational ISSS for upcoming simulations. The ISSS hardware is scheduled for implementation into the laboratory and will be used for ADL testing in FY-96.

Simulations in the En Route Laboratory can be conducted using either Host dynamic simulator (DYSIM) functions or the TGF capabilities to implement changes in aircraft status.

For DYSIM simulations, pilot positions are staffed by trained individuals positioned at other Host displays. Aircraft targets are manipulated in response to controller instructions through input into the Host system keyboard at their position.

For simulations using the TGF, pilot positions are staffed by trained individuals positioned at TGF consoles. Aircraft targets are manipulated by these individuals in response to controller instructions through input into the TGF system keyboard at their position.

4.5.2 Terminal Laboratories.

Terminal Laboratories emulate generic Terminal Radar Approach Control Facilities (TRACON's). Included are operational ARTS IIIA, ARTS IIIE, and ARTS II systems with controller displays, and operational communications systems. The laboratories can be
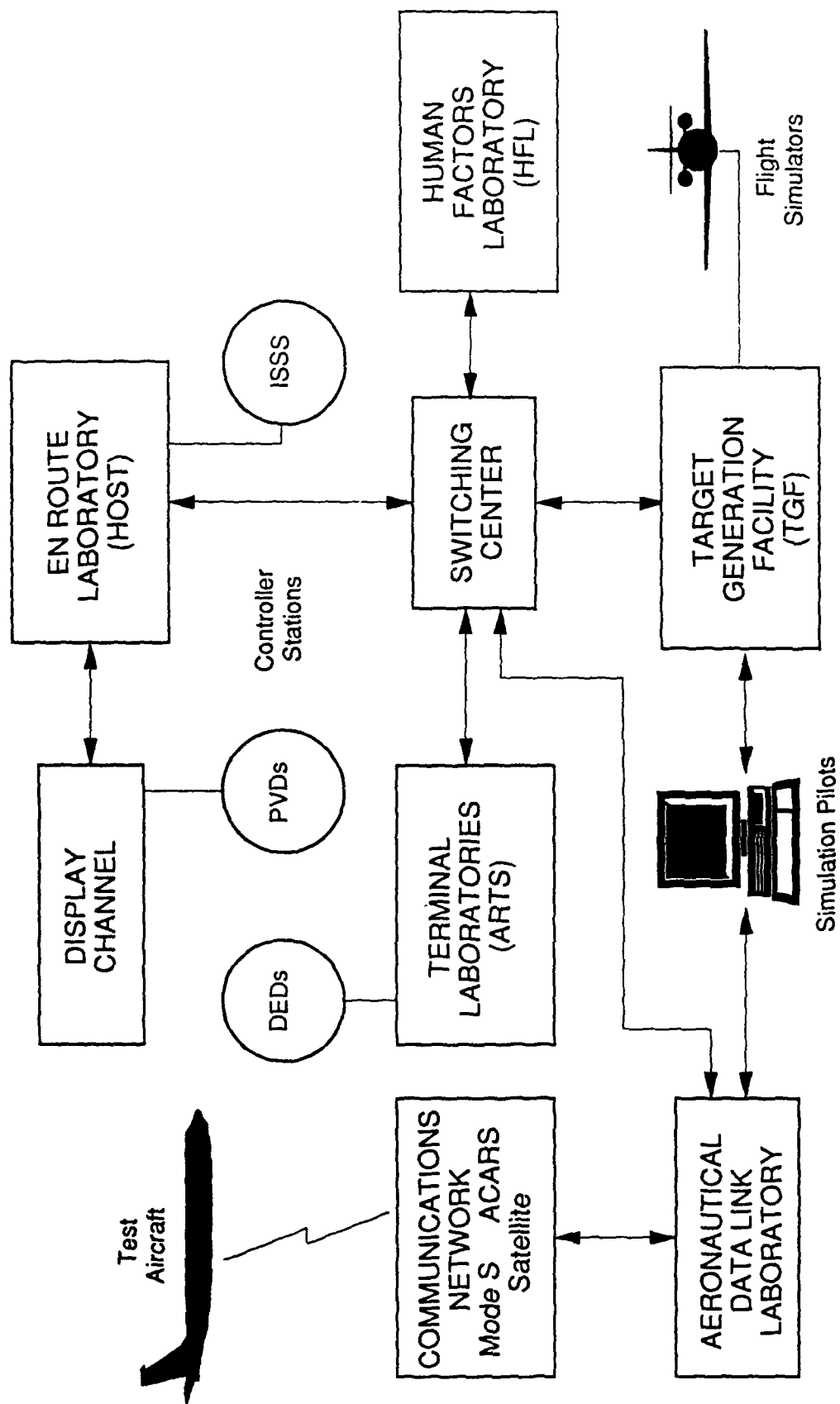
10

FIGURE 1. FAA TECHNICAL CENTER AERONAUTICAL DATA LINK TEST BED

configured to represent terminal airspace characteristics suited to experiment objectives.

Terminal Laboratory simulations can use either ARTS Extended Target Generation (ETG) functions or TGF capabilities to implement changes in aircraft status.

For ETG simulations, pilot positions are staffed by trained individuals positioned at other ARTS displays. Aircraft targets are manipulated in response to controller instructions through input into the ARTS keyboard at their position.

For simulations using the TGF, pilot positions are staffed by trained individuals positioned at TGF consoles. Aircraft targets are manipulated by these individuals in response to controller instructions through input into the TGF system keyboard at their position.

4.5.3 Human Factors Laboratory.

The FAA Technical Center's Human Factors Laboratory (HFL) is being developed for the purpose of investigating the human factors issues of the aviation industry. Extensive capabilities will be incorporated to enable a variety of system analyses to be conducted.

The HFL will house ISSS prototypes which will be used in the development and evaluation of ADL in the En route and Terminal environments prior to the availability of the actual ISSS build (FY-96). The HFL will also house the Reconfigurable Cockpit System (RCS). The RCS will emulate the basic functionality of major transport aircraft types. ADL capabilities will be incorporated. Additionally, the Center/TRACON Automation System (CTAS) hardware and software, upon which this traffic management tool is being developed and evaluated, will be located in the HFL.

The HFL and the systems it contains can be integrated with the En Route and Terminal Laboratories through the TGF. It is intended that any or all HFL capabilities be applied as needed to investigating ADL issues in a prototyping, part task, or end-to-end simulation mode.

4.5.4 ADL Laboratory.

The ADL Laboratory includes a VAX 11/750 computer system which emulates Data Link Processor (DLP) functions. The ADL Laboratory supports all digital communication between TGF pilots and the controllers in the En Route, Terminal, and HFL Laboratories.

5. ADL APPLICATIONS DEVELOPMENT SCHEDULE.

This section discusses development of ADL communications capabilities in the different operational environments for the various display systems. It outlines the steps in the development process including ADL functionality development.

Development of an ADL test bed at the FAA Technical Center was initiated for the purpose of examining ADL communication issues in the Terminal and the En Route environments. The test bed is designed to explore hardware and software alternatives in an environment which emulates current and future real-world operational conditions. Based upon the results of the ADL studies conducted in the test bed, specifications for ADL hardware, software, and policies and procedures for operational use of ADL capabilities will be developed.

The ADL test bed development schedule reflects the hardware and software implementation schedules for the ISSS, Terminal Advanced Automation System (TAAS), and Area Control Computer Complex (ACCC). The experiment schedule identifies tests needed to ensure orderly progress in developing ADL services for the several ATC environments.

5.1 EN ROUTE ENVIRONMENT.

The development of the ADL En Route test bed includes the evaluation of ADL on the Host/Plan View Display (PVD), development of initial services and traffic management functions on the ISSS prototype and the actual ISSS hardware. Additionally, the integration of ADL functions into the Area Control Facility (ACF) will be investigated. The schedule for testing and development is shown in figure 2.

5.1.1 HOST/PVD.

ADL development for the En Route environment has progressed to the point that an initial set of ATC Data Link services has been defined, evaluated, and demonstrated. A ground system functional specification has been produced for implementation on the Host/PVD. The initial service set includes TOC, IC, altitude instructions with crossing restrictions, communications backup, and an MT function (see section 3).

An evaluation of the initial service set is scheduled for the second quarter FY-1993. This evaluation will incorporate ADL equipped flight simulators to address end-to-end operational issues.

HOST/PVD

- INTERFACE TO ARTS IIIA
- INTERFACE TO ISSS PROTOTYPE
- INTERFACILITY TESTING

ISSS/PROTOTYPE

- PROTOTYPE EVALUATION
- INTERFACE TO HOST
- INTERFACILITY TESTING
- CTAS/TMT INTEGRATION
- PART TASK TESTING
- CTAS/TMT FLIGHT MANAGEMENT COMPUTER INTEGRATION
- INTERFACILITY TESTING

ISSS/BUILD

- ADL SOFTWARE DEVELOPMENT
- PART TASK TESTING
- PART TASK TESTING
- OPERATIONAL EVALUATION
- CTAS/TMT INTEGRATION
- PART TASK TESTING
- DEFINE FTMI INTERFACE
- PART TASK TESTING

FY 93	FY 94	FY 95	FY 96	FY 97

FIGURE 2. EN ROUTE ADL TEST BED DEVELOPMENT SCHEDULE

14

5.1.2 ISSS Prototype.

To enable uninterrupted ADL research, the FAA Technical Center is developing a SUN/UNIX based ISSS prototype to emulate the functionality of production ISSS hardware and software. The initial ADL service set, developed in the Host/PVD, will be incorporated. The ISSS prototype will be used for further evaluation of initial ADL services and to resolve human/computer interface design issues prior to implementation of operational ISSS's.

The ISSS prototype will operate in a stand-alone mode, exploiting its pilot simulation capabilities, during part task simulations and rapid prototype evaluations. Following initial evaluation, the ISSS prototype will be interfaced with the Host computer system. This coupling will enable evaluation of ADL when used to communicate with aircraft transitioning between sectors equipped with dissimilar display systems, i.e., Host/PVD's and Host/ISSS's. A simulation will be conducted in the fourth quarter FY-93 to test the interface.

The interface of the ISSS prototype to the Host computer also facilitates interfacility testing planned for FY-94. This testing will evaluate ADL when used to communicate with aircraft transitioning between Terminal and En Route sectors.

The ISSS prototype will also be used to develop additional ADL services and to support ADL incorporation into the evolving Traffic Management Tools (TMT). The development of these functions will commence in FY-94 and continue into FY-95. Two end-to-end simulations are planned to evaluate the interface designs and procedural implementations.

5.1.3 Production ISSS.

En Route ADL capability development on production ISSS equipment will begin at the FAA Technical Center in FY-95. Initial ADL services and the ADL services developed on the ISSS prototype will be transferred to the ISSS build. These will be tested during a simulation during the first quarter of FY-96.

TMT capabilities will be integrated into the ISSS build following successful testing of the expanded set of ADL services. Testing of TMT's will be conducted in FY-94 with emphasis toward the integration of ADL services into the ACF.

5.2 TERMINAL ENVIRONMENT.

The process employed in developing ADL capabilities for Terminal applications approximates that followed for the En Route environment, but is tailored to reflect the different processing and display equipments used. Terminal test bed efforts include evaluation of ADL on the ARTS IIIA, ARTS IIIE, ARTS II, and the

15

next generation Terminal ATC system (e.g., TAAS) implementation on the ISSS prototype. The schedule for testing and development is shown in figure 3.

5.2.1 ARTS IIIA.

ADL development for the Terminal environment has progressed to the point that an initial set of ATC Data Link services have been defined and evaluated. A ground system functional specification is under development for implementation on the ARTS IIIA. The initial service set includes TOC, IC, TI, and MT functions (see section 3).

An operational evaluation is planned for the first quarter FY-93. This activity will incorporate ADL equipped flight simulators to address end-to-end operational issues.

Incorporation of ADL capabilities into evolving traffic management capabilities will commence in FY-94. TMT's, such as metering and spacing functions, will be developed for integration in the ARTS IIIA system. ADL will enable direct transfer of computer developed flightpath and flight plan changes to aircrews in a quick and efficient manner.

Implementation of ADL transfer of traffic management messages will be tested at the FAA Technical Center using prototyping and part task evaluations. These tests will be directed towards the evaluation of system development and human factors issues as they relate to system operation and safety. Potential airspace capacity increases and controller workload decreases will be measured.

Two end-to-end simulations of ARTS IIIA TMT capabilities are planned in FY-94 to evaluate interface designs and investigate procedural implications.

5.2.2 ARTS IIIE and ARTS II.

Development of initial ADL services for the ARTS IIIE and ARTS II will commence upon the completion of the operational demonstration of the ARTS IIIA. To the extent practical, prototyping and part task analyses will be used to acquire the knowledge necessary to complete a functional specification. These analyses will be conducted throughout FY-93.

5.2.3 ISSS Prototype.

Operational Test and Evaluation of the TAAS is scheduled to commence FY-97 at the FAA Technical Center. During FY-95, the ISSS prototype will be used to evaluate operational ATC changes associated with implementation of the next generation Terminal ATC system (such as TAAS) to facilitate timely integration of ADL. As ADL services are developed for the next generation Terminal ATC
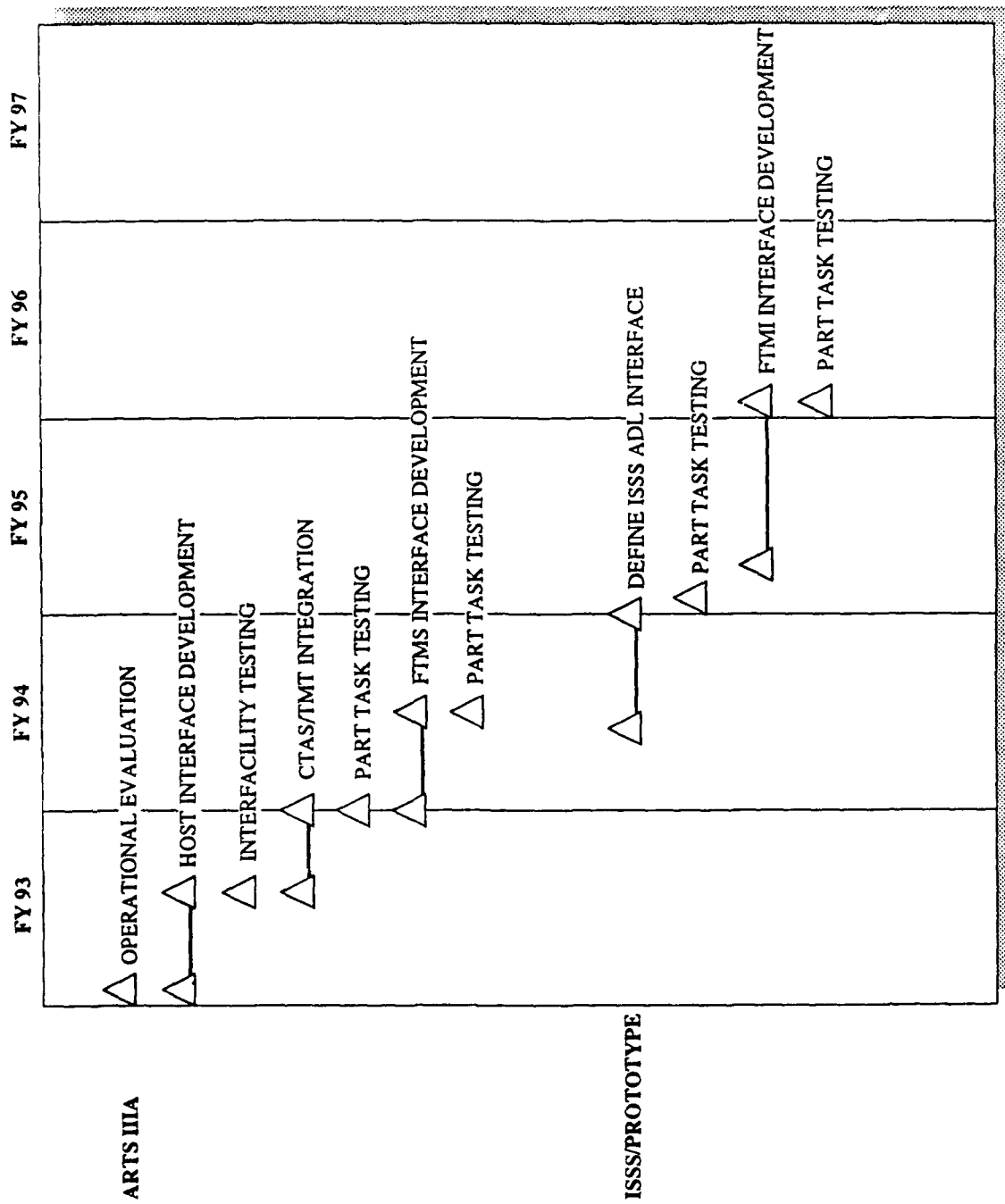
16

FIGURE 3. TERMINAL ADL TEST BED DEVELOPMENT SCHEDULE

17

System, a parallel effort to investigate aircrew use of direct input of ATC messages into the Flight Management System (FMS) will be undertaken.

6. RESEARCH SCHEDULE.

The ADL Research Plan accommodates a variety of constraining factors including NAS hardware and software development and implementation schedules and the necessity to investigate general human factors issues, the resolution of which will likely influence design decisions. The research plan, therefore, has the dual objective of addressing ADL service design development issues and issues relating to the human component of the ultimate system. In many cases, both roles of the plan are complementary and are scheduled to be carried out simultaneously.

This section of the plan describes a series of simulations (primarily end-to-end) that are designed to evaluate implementation of ADL in the ground ATC environment. Because ADL is the connecting communication medium between ground and airborne nodes, it is essential that the airborne component of the system be considered in making design judgements. Accordingly, the plan includes use of suitably equipped flight simulators as a major feature.

Ensuring that ADL "customer" concerns were appropriately addressed was a major consideration in constructing the plan. ADL customers include both ATC service providers (the FAA's Air Traffic Division) and ATC service users (aircraft operators). Many of their concerns have been documented by industry organizations, in particular the ATA ADL Human Factors Committee and the SAE G10-K subcommittee. These working groups, which comprise representatives from both groups, have identified many issues concerning ADL which require examination (see section 7).

End-to-end simulations are organized in the following sections by operational environment, i.e., En Route, Terminal, and Interfacility. The first two address issues unique to their respective environment, the third addresses issues which cross environment boundaries. Each simulation is presented separately. Simulation objective(s), methodology, and expected results are provided. Where appropriate, the genesis of the issue is also identified.

Simulations are sequenced to permit incorporation of the body of knowledge gained from prior efforts into following efforts. It should be noted that ADL design development evaluations will not be limited to the simulations those identified in this schedule. Part task simulations and rapid prototype analyses will be conducted when required prior to the end-to-end simulations. This approach permits investigation of issues that can be isolated and

analyzed without incurring the greater expense of end-to-end simulations.

6.1 EN ROUTE ENVIRONMENT.

The following section describes the proposed schedule for evaluating ADL in the En Route environment. The simulation chronology, including approximate test dates and simulation objectives, is shown in figure 4.

6.1.1 Activity E1.

ISSS Controller Interface Design Evaluation.

6.1.1.1 Objective.

Evaluate controller interface issues for transitioning initial En Route services to the ISSS.

This simulation addresses SAE-G10 issue 12, Definition of Human Interface Requirements.

6.1.1.2 Methodology.

Part Task. Transition current Host/PVD services to ISSS prototype. Use teams of controllers to evaluate system design and enhanced ISSS ADL capabilities.

6.1.1.3 Expected Results.

Initial design requirements for the implementation of ADL on production ISSS and identification of enhanced ISSS ADL functions.

6.1.2 Activity E2.

ADL Effects on Controller and Pilot Performance.

6.1.2.1 Objective.

Assess influence of ADL use on controller and pilot performance. Develop initial operational procedures for ADL use.

This simulation addresses SAE G-10 issue 11, Crew Controller Expectations Effect Message Interpretation and SAE G-10, issue 17, Impact on ATC System Capacity.

6.1.2.2 Methodology.

En route end-to-end simulation. Use Host/PVD laboratory and flight simulators. Use a team of controllers and airline pilot volunteers to exercise ADL capabilities.
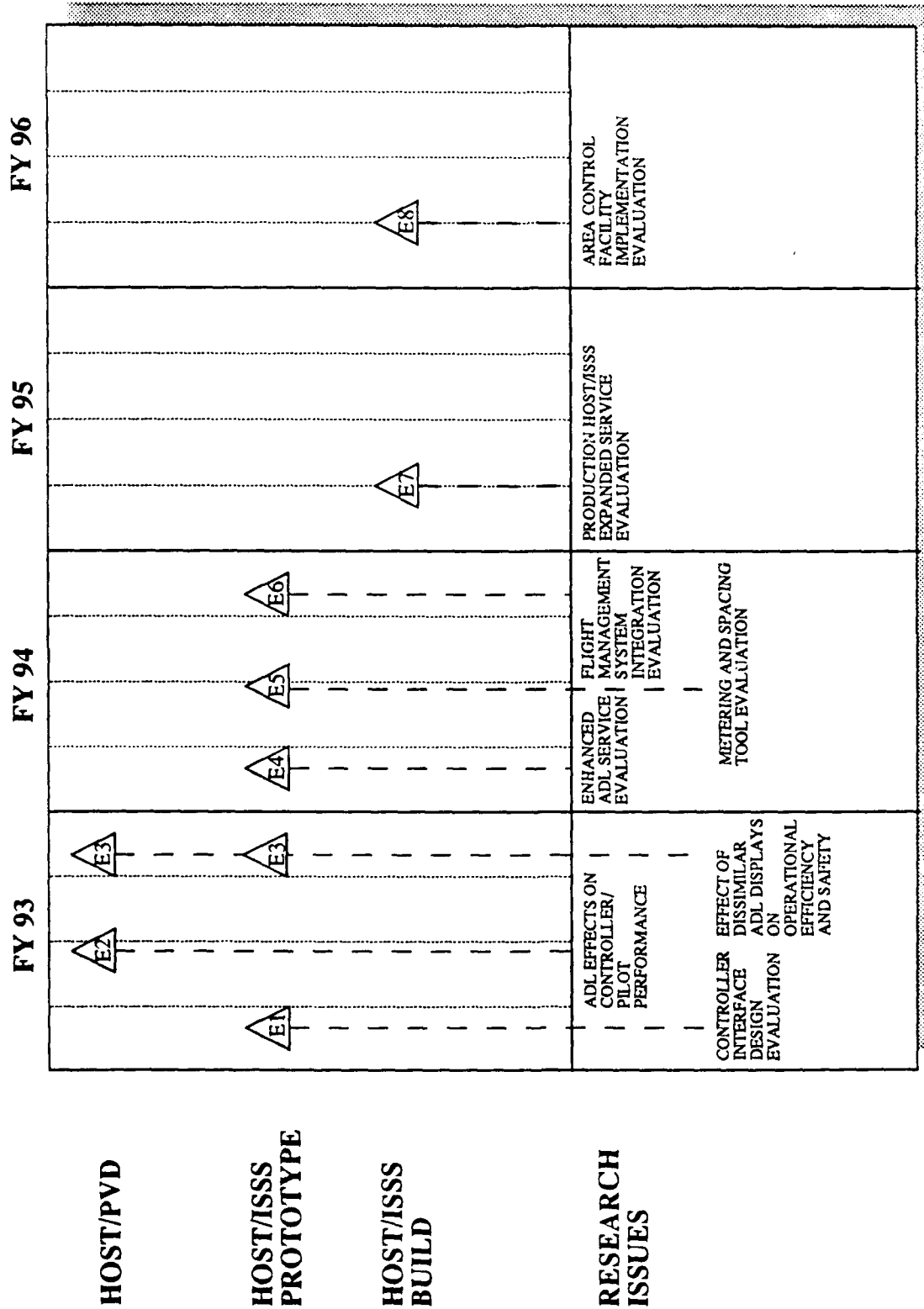
19

FY 93 FY 94 FY 95 FY 96

HOST/PVD

HOST/ISSS PROTOTYPE

HOST/ISSS BUILD

RESEARCH ISSUES

E1 E2 E3 E3 E4 E5 E6 E7 E8

ADL EFFECTS ON CONTROLLER/ PILOT PERFORMANCE

ENHANCED ADL SERVICE EVALUATION

FLIGHT MANAGEMENT SYSTEM INTEGRATION EVALUATION

PRODUCTION HOST/ISSS EXPANDED SERVICE EVALUATION

AREA CONTROL FACILITY IMPLEMENTATION EVALUATION

CONTROLLER INTERFACE DESIGN EVALUATION

EFFECT OF DISSIMILAR ADL DISPLAYS ON OPERATIONAL EFFICIENCY AND SAFETY

METERING AND SPACING TOOL EVALUATION

FIGURE 4. EN ROUTE ENVIRONMENT ADL SIMULATION SCHEDULE

20

6.1.2.3 Expected Results.

Measured effects of response delays on ADL use in terms of controller, pilot, and system efficiency (i.e., reduced flight delays and increased airspace capacity). Quantitative and qualitative data on the ability of controllers and aircrews to adjust communication strategies to compensate for delays in ADL message response times. A set of recommended delay mitigation procedures. A set of recommended operational procedures.

6.1.3 Activity E3.

Host/ISSS to Host/PVD Operational Comparison.

6.1.3.1 Objective.

Examine effects of dissimilar ADL display systems on operational efficiency and safety.

In part, this simulation explores SAE G-10 issue 7, Human Error Detection.

6.1.3.2 Methodology.

En route end-to-end simulation. Use Host/PVD and ISSS prototype laboratories and flight simulators. Perform an en route end-to-end simulation in which aircraft transition between Host/PVD sectors and ISSS sectors. Use a team of controllers and airline pilot volunteers to exercise the ADL capabilities. Measure effects.

6.1.3.3 Expected Results.

Identification of risks associated with transitions between airspaces with dissimilar ADL display capabilities. Recommended risk reduction approaches. Quantification of differences in controller and pilot performance when operating in airspaces with dissimilar ADL display capabilities. Additional design requirements for the implementation of ADL on the production ISSS.

6.1.4 Activity E4.

Enhanced ADL Service Evaluation.

6.1.4.1 Objective.

Assess the influence of new ADL services including metering and spacing applications on controller and pilot situation awareness.

This simulation examines ATA Research Agenda item L, "Effects of Data Communication on Crew Alertness"; SAE G-10 issue 10, "Crew/Controller Situation Awareness"; SAE G-10 item 16,

"Automation-Function Allocation"; and, supports procedure development recommendations cited by ATA Research Agenda item A and SAE-G10 issue 3.

6.1.4.2 Methodology.

En route end-to-end simulation. Use ISSS prototype and flight simulators. Use a team of controllers and airline pilot volunteers to exercise ADL capabilities.

6.1.4.3 Expected Results.

Validation of the operational utility of the added services. Quantification of the effects of using ADL to transfer ATC instructions on (1) controller awareness of aircraft positions and intentions, and (2) pilot awareness of air traffic activity and flight conditions. Quantification of the effects of automated ATC instruction generation using metering and spacing tools on controller awareness. Initial quantification of the operational benefits of ADL enabled metering and spacing applications.

6.1.5 Activity E5.

Metering and Spacing Tool Evaluation.

6.1.5.1 Objective.

Assess the effect of using ADL enabled metering and spacing tools on controller and system efficiency.

This simulation will address SAE G-10 issue 17, "Impact of ADL on ATC System Capacity."

6.1.5.2 Methodology.

En route end-to-end simulation. Use ISSS prototype and flight simulators. Use a team of controllers and airline pilot volunteers to exercise ADL and metering and spacing tool capabilities.

6.1.5.3 Expected Results.

Quantification of metering and spacing tools effects on controller and ATC system efficiency (i.e., reduced flight delay and increased airspace capacity). A recommended set of ADL metering and spacing applications procedures.

6.1.6 Activity E6.

FMS Integration Evaluation.

6.1.6.1 Objective.

Assess the effects of direct ATC message exchange between ground ATC computers and aircraft FMS computers using ADL. Measure effects on controller, pilot, and system efficiency, flight delay, and airspace capacity.

This simulation examines ATA Research Agenda item L, "Effects of Data Communication on Crew Alertness"; SAE-G10 issue 10, "Crew/Controller Situation Awareness," SAE-G10 issue 16, "Automation-Function Allocation," and SAE-G10 issue 17, "Impact of ADL on ATC System Capacity."

6.1.6.2 Methodology.

En route end-to-end simulation. Use ISSS prototype and flight simulators. Use a team of controllers and airline pilot volunteers to exercise the ADL capabilities.

6.1.6.3 Expected Results.

Quantification of the effects of ADL coupled ATC and FMS computers on controller, pilot, and system efficiency (i.e., reduced flight delay and increased airspace capacity). Identification of operational risks associated with coupling ATC and FMS computers via ADL. Recommended risk reduction approaches.

6.1.7 Activity E7.

Production Host/ISSS Expanded Service Evaluation.

6.1.7.1 Objective.

Evaluate production Host/ISSS ADL controller interface with emphasis on controller performance.

This simulation will address SAE-G10 issue 12, "Definition of Human Interface Requirements."

6.1.7.2 Methodology.

En route end-to-end simulation. Use production Host/ISSS and flight simulators. Use a team of controllers and airline pilot volunteers to exercise ADL capabilities.

6.1.7.3 Expected Results.

Identification and quantification of operational benefits and risks associated with the integration of ADL functions into the Host/ISSS build.

6.1.8 Activity E8.

ACF Implementation Evaluation.

6.1.8.1 Objective.

Evaluate benefits and risks associated with ADL use in an ACF environment.

This simulation will explore SAE G-10 issue 6, "Procedural Guidelines for Using the System."

6.1.8.2 Methodology.

En route end-to-end simulation. Use production Host/ISSS and flight simulators. Use a team of controllers and airline pilot volunteers to exercise the ADL capabilities.

6.1.8.3 Expected Results.

Initial analysis of the effect of En Route ACF operations on ADL use. The study will examine controller, pilot, and system efficiencies when using ADL in the ACF environment.

6.2 TERMINAL ENVIRONMENT.

The following section describes the proposed schedule for evaluating ADL in the Terminal environment. The simulation chronology, including approximate test dates and simulation objectives, is shown in figure 5.

6.2.1 Activity T1.

Operational Evaluation of Initial Terminal ADL Services.

6.2.1.1 Objective.

Validate initial Terminal ADL services and quantification of benefits and risks associated with ADL use in Terminal airspace.

This simulation examines ATA Research Agenda item L, "Determine the Effects of Data Communications on Crew Alertness," SAE G-10 issue 10, "Crew/Controller Situation Awareness," SAE G-10 issue 13, "Determine Workload Impact of Data Link Implementation," and SAE G-10 issue 17, "Impact of Data Link on System Capacity." The
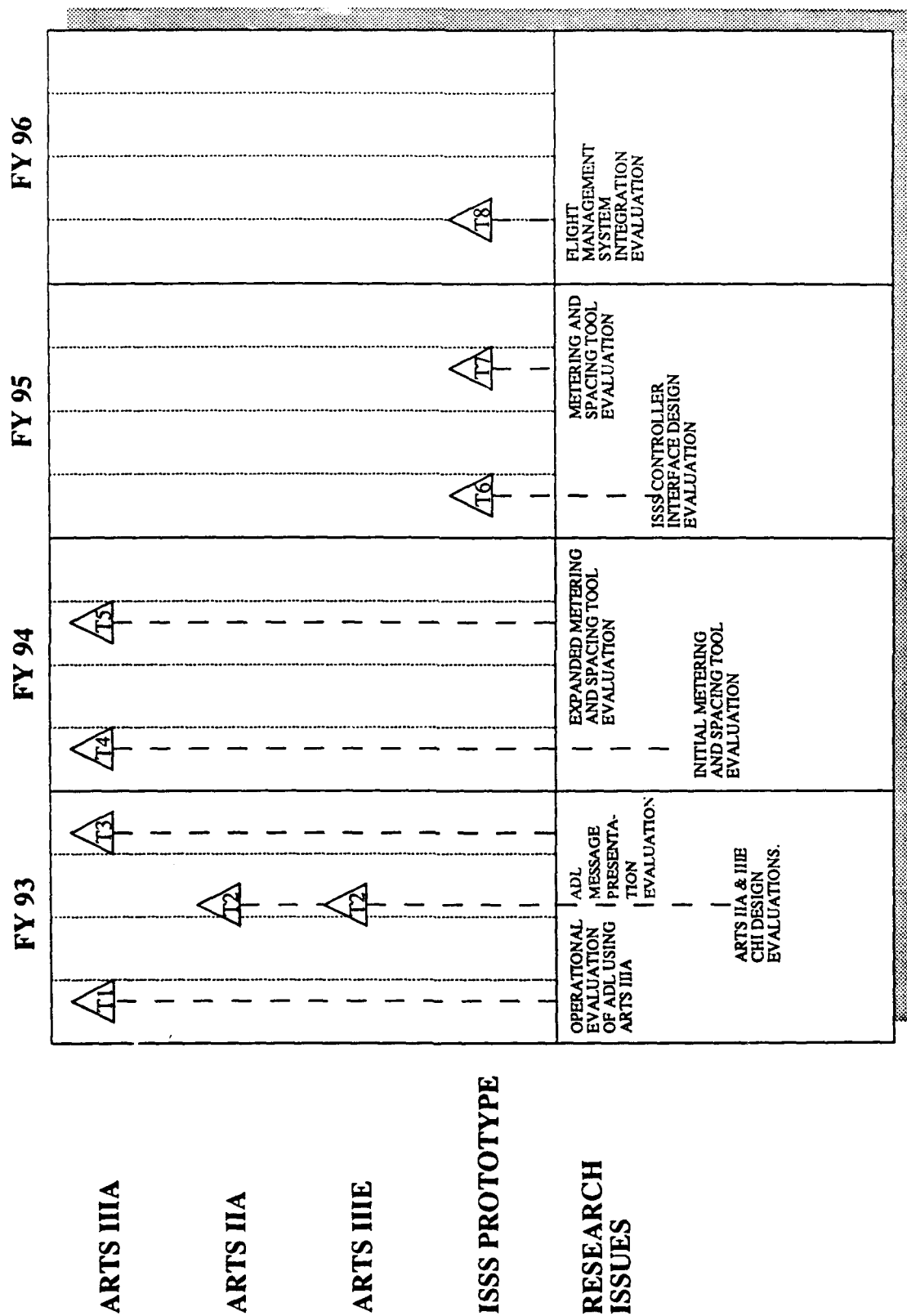
FIGURE 5. TERMINAL ENVIRONMENT ADL SIMULATION SCHEDULE

25

simulation also supports the objectives of ATA Research Agenda items A and C, and SAE G-10 issue 3.

6.2.1.2 Methodology.

Terminal end-to-end simulation. Use ARTS IIIA laboratory and flight simulators. Use a team of controllers and airline pilot volunteers to exercise ADL capabilities.

6.2.1.3 Expected Results.

Validated initial Terminal ADL services. Quantitative and qualitative data on the controller and aircrew performance when using initial Terminal ADL services. Quantified system performance benefits resulting from use of initial Terminal ADL services.

6.2.2 Activity T2.

ARTS II and ARTS IIIE CHI Design Evaluation.

6.2.2.1 Objective.

Develop ADL System Level Specification for the ARTS II and ARTS IIIE systems.

This simulation will address SAE G-10 issue 12, "Definition of Human Interface Requirements and ATA Research Agenda item C."

6.2.2.2 Methodology.

Prototype Testing. Transfer ARTS IIIA ADL capabilities to FAA Technical Center ARTS II and ARTS IIIE workstations. Use teams of controllers to evaluate CHI designs.

6.2.2.3 Expected Results.

ARTS II and ARTS IIIE System Level Specifications.

6.2.3 Activity T3.

ADL Message Presentation Evaluation.

6.2.3.1 Objective.

Evaluate context, content, and coding of phraseology and abbreviations used in ADL communications to validate suitability for operational use. Optimize display presentation of ADL messages.

This simulation addresses SAE G-10 issue 7, "Human Error Detection," SAE G-10 issue 8, "Message Prioritization and

Integration," and SAE G-10 issue 11, "Crew and Controller Expectations Can Effect Message Interpretation."

6.2.3.2 Methodology.

Terminal end-to-end simulation. Use ARTS IIIA laboratory and flight simulators. Establish stress workload conditions. Introduce communication errors. Use a team of controllers and airline pilot volunteers to exercise the ADL capabilities.

6.2.3.3 Expected Results.

Validated ADL uplink and downlink message sets. Identification of nonoptimal message constructs. Recommended approaches to correct. Optimized display presentations.

6.2.4 Activity T4.

Initial Metering and Spacing Tool Evaluation.

6.2.4.1 Objective.

Assess effects of ADL enabled metering and spacing tools on controller efficiency and airspace capacity. Assess controllers' ability to detect and resolve conflicts.

This simulation will address SAE G-10 issue 17, "Impact of Data Link on ATC System Capacity," SAE G-10 issue 10, "Crew/Controller Situational Awareness," and ATA Research Agenda item L, "Determine Effects of Data Communication on Crew Alertness."

6.2.4.2 Methodology.

Part task simulation. Use ARTS IIIA laboratory and the FAA Technical Center TGF pilot simulators. Use team of controllers to exercise metering and spacing tool and ADL capabilities.

6.2.4.3 Expected Results.

Quantitative data on air traffic flow improvements due to controller efficiency gains. Identification of potential conflict detection and resolution risks. Recommended risk mitigation approaches.

6.2.5 Activity T5.

Expanded Metering and Spacing Tool Evaluation.

6.2.5.1 Objective.

Assess effects of ADL enabled metering and spacing tools on controller efficiency and airspace capacity. Assess controllers' ability to detect and resolve conflicts.

This simulation extends Initial Metering and Spacing Tool Evaluation efforts. Traffic levels are increased and aircraft simulators are included.

This simulation addresses SAE G-10, issue 17, "Impact of Data Link on ATC System Capacity," SAE G-10 issue 10, "Crew/Controller Situational Awareness," and ATA Research Agenda item L, "Determine Effects of Data Communication on Crew Alertness."

6.2.5.2 Methodology.

Terminal end-to-end simulation. Use ARTS IIIA laboratory and flight simulators. Establish stress workload conditions. Use a team of controllers and airline pilot volunteers to exercise the ADL capabilities.

6.2.5.3 Expected Results.

Quantitative data on air traffic flow improvements and potential g ins in airspace capacity due to integration of ADL and metering and spacing tools. Identification of potential conflict detection and resolution risks. Recommended risk mitigation approaches. A recommended set of ADL metering and spacing applications procedures.

6.2.6 Activity T6.

Next Generation Terminal ATC System ADL Interface Design Definition.

6.2.6.1 Objective.

Evaluate controller interface issues for ADL use with the next generation terminal ATC system (e.g., TAAS).

This simulation addresses SAE G-10 issue 12, "Definition of Human Interface Requirements."

6.2.6.2 Methodology.

Prototyping. Transition validated Terminal ADL services to ISSS Prototype modified to comply with design constructs of the next

generation terminal ATC system (e.g., TAAS). Use teams of controllers to evaluate system design and capabilities.

6.2.6.3 Expected Results.

Initial design requirements for the implementation of ADL in the next generation terminal ATC system.

6.2.7 Activity T7.

Next Generation Terminal ATC System and Metering and Spacing Tool Integration Evaluation.

6.2.7.1 Objective.

Assess effects of metering and spacing tools on controller efficiency and airspace capacity.

This simulation will address SAE G-10 issue 17, "Impact of ADL on ATC System Capacity."

6.2.7.2 Methodology.

Terminal end-to-end simulation. Use ISSS prototype modified to comply with design constructs of the next generation terminal ATC system (e.g., TAAS) and flight simulators. Use a team of controllers and airline pilot volunteers to exercise ADL and metering and spacing tool capabilities.

6.2.7.3 Expected Results.

Quantification of the effects of metering and spacing applications on airspace capacity and controller and pilot efficiency.

6.2.8 Activity T8.

Next Generation Terminal ATC System and FMS Integration Evaluation.

6.2.8.1 Objective.

Assess the effect of automatic transfer of ATC messages (including metering and spacing) into aircraft FMS's on controller and pilot situation awareness, and controller, pilot, and system efficiency (i.e., reduced flight delay and increased airspace capacity).

This simulation examines ATA Research Agenda item L, "Effects of Data Communication on Crew Alertness," SAE G-10 issue 10, "Crew/Controller Situation Awareness," SAE G-10 issue 16, Automation-Function Allocation," and SAE G-10 issue 17, "Impact of ADL on ATC System Capacity."

29

<u>6.2.8.2 Methodology</u>.

Terminal end-to-end simulation. Use ISSS prototype modified to comply with design constructs of the next generation terminal ATC system (e.g., TAAS) and flight simulators. Use a team of controllers and airline pilot volunteers to exercise metering and spacing tool and ADL capabilities.

<u>6.2.8.3 Expected Results</u>.

Identification of operational risks associated with coupling ATC and FMS computers via ADL. Recommended risk reduction approaches. Quantification of the effects of ADL coupled ATC and FMS computers on controller and pilot situation awareness, and controller, pilot, and system efficiency (i.e., reduced flight delay and increased airspace capacity).

<u>6.3 INTERFACILITY TESTING</u>.

Interfacility testing will involve concurrent simulation of adjacent En Route and Terminal air spaces for the purpose of evaluating the ADL system. The interfacility testing will provide an assessment of ADL's capability to improve NAS operations.

The following section presents the proposed schedule for evaluating the use of ADL communication for aircraft which transit between the En Route and Terminal environments. The simulation chronology, including approximate test dates and simulation objectives, is shown in figure 6. To establish a context for the reader, complementary En Route and Terminal activities are also included.

<u>6.3.1 Activity I1</u>.

Operational Evaluation. Integrated Host/PVD - Host/ISSS - ARTS IIIA.

<u>6.3.1.1 Objective</u>.

Examine effects of dissimilar ADL display systems on controller, pilot, and system efficiency and on flight safety.

This simulation addresses SAE G-10 issue 7, "Human Error Detection," SAE G-10 issue 13, "Determine Workload Impact," and SAE G-10 issue 23, "Implications of Dual Operations."

<u>6.3.1.2 Methodology</u>.

End-to-end simulation. Use Host/PVD, ISSS prototype, and ARTS IIIA laboratories and flight simulators. Use a team of controllers and airline pilot volunteers to exercise ADL capabilities.

FIGURE 6. INTERFACILITY ADL SIMULATION SCHEDULE

31

6.3.1.3 Expected Results.

Identification of risks associated with transitions between airspaces with dissimilar ADL capabilities. Quantification of differences in controller and pilot performance when operating in airspaces with dissimilar ADL capabilities. Recommended risk reduction approaches.

6.3.2 Activity I2.

Operational Evaluation. Integrated Host/ISSS - ARTS IIIA with Metering and Spacing Tools.

6.3.2.1 Objective.

Assess effects of metering and spacing tools on controller and pilot situation awareness, on controller, pilot, and system efficiency (i.e., reduced flight delay and increased airspace capacity), and on flight safety.

This simulation examines ATA Research Agenda item L, "Effects of Data Communication on Crew Alertness," SAE G-10 issue 10, "Crew/Controller Situation Awareness," and SAE G-10 item 16, "Automation-Function Allocation."

6.3.2.2 Methodology.

End-to-end simulation using the ISSS prototype and ARTS IIIA laboratories and flight simulators. Use a team of controllers and airline pilot volunteers to exercise the ADL capabilities.

6.3.2.3 Expected Results.

Quantification of the effects of using ADL to transfer ATC instructions on controller awareness of aircraft positions and intentions and pilot awareness of air traffic activity and environmental conditions. Quantification of the effect of automated ATC instruction generation (via metering and spacing tools) on controller, pilot, and system efficiency (i.e., reduced flight delay and increased airspace capacity).

6.3.3 Activity I3.

Operational Evaluation. Integrated Host/ISSS - Next Generation Terminal ATC System with Metering and Spacing Tools and FMS.

6.3.3.1 Objective.

Assess the effect of automatic transfer of ATC messages (including metering and spacing) into aircraft FMS's on controller and pilot situation awareness, on controller, pilot, and system efficiency

(i.e., reduced flight delay and increased airspace capacity), and on flight safety.

This simulation examines ATA Research Agenda item L, "Effects of Data Communication on Crew Alertness," SAE-G10 issue 10, "Crew/Controller Situation Awareness," SAE-G10 issue 16, "Automation-Function Allocation," and SAE-G10 issue 17, "Impact of ADL on ATC System Capacity."

6.3.3.2 Methodology.

End-to-end simulation. Use Host/ISSS and ISSS prototype modified to comply with design constructs of the next generation terminal ATC system (e.g., TAAS) and flight simulators. Use a team of controllers and airline pilot volunteers to exercise ADL capabilities.

6.3.3.3 Expected Results.

Identification of operational risks associated with coupling ATC and FMS computers via ADL. Recommended risk reduction approaches. Quantification of the effects of ADL coupled ATC and FMS computers on controller and pilot situation awareness, and controller, pilot, and system efficiency (i.e., reduced flight delay and increased airspace capacity).

7. HUMAN FACTORS ISSUES.

Human factors issues which require resolution for ADL to be successfully implemented have been documented by several organizations. The SAE Subcommittee G-10 Flight Deck Information Management and the ATA Human Factors Working Group have both documented many of the significant issues regarding ADL implementation (SAE ARD50027 and the ATA Proposed Research Agenda for Data Link). Research conducted at the FAA Technical Center, NASA-Ames, and NASA Langley have examined several of the ATC and flight deck related human factors issues for ADL operations. The issues discussed below were derived from a consideration of this previous work and open discussions with FAA ATC operational and research personnel, SAE, ATA, airline industry personnel, and other government agencies. This is not intended to be a complete list of human factors issues. It is only intended to identify time critical issues which can be addressed at the FAA Technical Center.

The list of human factors issues can be categorized into three areas, ATC, flight deck, and ATC/flight deck integration. Strictly speaking, ATC human factors issues are those which directly relate to the controller's ability to control traffic. ATC issues deal mainly with controller display designs and related issues. Similarly, flight deck issues are those issues that directly affect the aircrew's ability to perform their tasks. ATC/flight deck integration issues deal with the interchange of

information between ATC and the flight deck. Because the controllers and pilots together attempt to achieve the common goal of safe flight operations, the issues concerning ATC/flight deck integration need to be considered using a systems approach. The systems approach quantifies the relationships between the individual components of the system and the contribution of each component toward the common goal.

The emphasis of this research plan is the development of a schedule of studies designed to explore human factors issues of the integration of ADL into the ATC/flight deck "system." The goal of the research is to enable system designers to develop an ADL communication system which provides benefits to the both user groups during all levels of integration.

The issues relating to ATC/flight deck integration can be categorized into three general areas: Communication Policies and Procedures, Controller/Aircrew Situational Awareness and Performance, and Human Interface Requirements. A discussion of several issues within each of these areas is presented in the following sections. Although each of these issues will be discussed individually, each issue is related to the other topics. When evaluating situational awareness for example, the specific interface design, procedures, and the chosen policies must all be taken into consideration.

Many of the issues are common among operational ATC environments and phases of flight. The knowledge gained from exploring an issue in one environment can frequently be applicable in another environment. There will, however, be differences in the research questions answered between operational environments. The following discussion of research issues includes a table of candidate research questions for each operational environment. As ADL is developed, additional research issues may be identified and will be incorporated into the development schedule.

7.1 COMMUNICATIONS SYSTEM USAGE.

With the implementation of ADL into the operational environment, controllers and aircrews will be able to choose the communication system for message transmittal. Policies and procedures for the use of both communication systems need to be developed to ensure that messages are transmitted and received in a timely manner, that message transmission does not overburden either the individual transmitting the message or the receiver of the message, and that the message is clear and not open to misinterpretation. The following section provides an overview of the human factors issues concerning the policies and procedures of communication system usage.

7.1.1 Communication System Policies.

The communication system policies, or rules, for voice communication have been developed based upon many years of operational experience. Their development has ensured the safe operation of aircraft within the NAS. With the development of a new complementary communications system, ADL, the policies for communication system usage need to be reassessed.

The policies for a multiple communication environment will define the appropriate communications media, voice or ADL, for specific message transmissions. A set of criteria that defines conditions under which ADL could be effective must be defined. Based upon these criteria and test evaluations, ADL policies will be developed for the different types of ATC facilities (En Route, Terminal, or Oceanic) and the different flight phases.

There are many questions relating to the communication system policies which require research. Candidate research questions for communication system policies are included in table 1.

TABLE 1. SAMPLE ADL INTEGRATION RESEARCH QUESTIONS -
COMMUNICATIONS PROTOCOL AND PROCEDURES

Does the use of ADL for TOC, TI/IC, ATC clearances, and ATC instructions improve AT efficiency (i.e., decreased workload or improved flightpaths) without reductions in safety or increases in error occurrences?

Which message types are inappropriate for ADL transmission in the various environments and flight phases?

Is voice communication channel usage reduced?

Should ADL messages require responses via ADL?

What effect does the transfer of ATC instructions generated by metering and spacing tools have on system efficiency?

What are the procedures for ATC clearance/ instruction negotiation between ATC and the aircrew (i.e., is it appropriate to negotiate using ADL or should the ADL message be closed and negotiation be done via voice communication)?

35

7.1.2 Communication System Procedures.

ADL procedures must be developed to accommodate all possible mixes of ADL services and voice communications. As ADL is developed, operational environments and aircraft may differ in their level of ADL capabilities. As controllers and aircrews become accustomed to the initial set of ADL services, procedures may be developed to manage that set in the most convenient method. The ADL procedures need to be developed such that they provide flexibility for the development of future services and do not cause inconveniences when the voice channel must be used.

7.2 SITUATIONAL AWARENESS AND PERFORMANCE.

The controller's and aircrew's ability to mentally visualize their environment and the effects of their actions on others in that environment is an important factor in the safety of aviation.

Controllers and aircrew members use many direct and indirect sources of information in developing their situational awareness or understanding of that environment. The following section addresses the human factors issues associated with ADL implementation that may influence the controller's and aircrew's situational awareness. Sample research questions that address controller situational awareness and performance issues are included in table 2.

7.2.1 Message Response Delays.

In today's operational environment, ATC messages are transferred between controllers and aircrew via voice communication. When a message is transmitted, a verbal response is expected shortly after the message has been completed. If a timely response is not received, controllers or pilots will transmit duplicate messages until a response is received. The "timeliness" of the message response is based upon several factors including flight phase, ATC environment, and controller and pilot expectations/previous experience. Just as controllers and aircrews have developed expectations for timely message response to voice communication, they will develop expectations of ADL communications.

The message response resulting from an ADL message may not occur in the same time frame as would be expected with voice communication. With ADL, some messages will receive a quicker response while others may result in increased response times.

This will be balanced by the controller's capability of transmitting more messages in a given amount of time.

Human performance principles have shown that individuals can adapt control strategies to account for delays in system response. Real-time ADL simulations conducted at the FAA Technical Center have

36

shown that controllers adjusted their strategies in accordance with different average pilot response delays. Typically, when delays were consistently longer, controllers issued ATC instructions to the aircrew proportionally earlier. This compensated for the additional delay in message response times. The range of response delays which the controller can compensate must be examined. Controllers may have problems if delays become unpredictable. Large or random variations in message response times will reduce the controller's ability to compensate for delays, thus making ATC via ADL less efficient. Additionally, unpredictably long delays in message response times may result in the controller initiating a second or third message to the aircraft before a response is received from the first message. Without additional procedural rules, problems may occur on the flight deck if multiple messages are conflicting in nature.

TABLE 2.   SAMPLE ADL INTEGRATION RESEARCH QUESTIONS -
CONTROLLER/AIRCREW SITUATIONAL AWARENESS
AND PERFORMANCE

Are controllers/aircrews able to formulate action plans that account for predictable delays in message response times?

Do variations in message response times affect the controller's or aircrews ability to compensate for expected delays?

Will automation of message transfers influence the controller's knowledge of aircraft positions and/or intentions?

Will the reduction of voice communication traffic affect the controller's/aircrew's knowledge of the movement and positions of aircraft in their vicinity or along their intended flightpath?

Will the dependence on ADL for communication cause errors in the transmission of messages via voice communication?

Will controllers be responsible for transmitting information concerning obstructions or delays previously available through the "party line" to other aircraft?

7.2.2 Message Transfer Automation.

Currently, most messages transmitted to the flight deck from the controller are voice radio communications. These interactions require the controller to identify the message recipient and the message content. By verbalizing the aircraft call sign and the ATC message, the controller is reinforcing his short term memory and developing his situational awareness. The ability to quickly assess changes in the environment are enhanced by the controller's retention of this information.

With ADL, a majority of the routine ATC-to-flight deck interactions will be done via ADL communication. This will result in the controller verbalizing ATC instructions and aircraft call signs less frequently. Messages are sent via ADL by selecting a message from a menu, for example, then slewing to the target aircraft and activating the transfer. By not verbalizing the call sign and the message, controllers may have reduced situational awareness. Controllers participating in the simulations at the FAA Technical Center have reported that when using ADL they were not able to recall contents of messages sent or whether messages were sent to specific aircraft.

ADL studies must examine the amount of information retained by controllers when using ADL and how much of this information is necessary. This should be compared with the results when controllers are using voice communication. These studies should examine information retention during routine operations and during extreme cases (i.e., during light versus heavy traffic).

7.2.3 Party Line.

During flight, aircrews often receive information about weather, traffic density, airport operations, and airport delays from the voice communications of other aircraft. Crews will monitor the radio frequency to evaluate movement and positions of other aircraft in their area. The availability of incidental information by monitoring other aircraft communications is often referred to as the "party line" effect. The party line is perceived to enable the aircrew and controllers to anticipate future actions and messages. Sources and types of information that aid controllers and aircrews, currently provided via party line, must be evaluated. Additionally, party line information sources that mislead aircrews and pilots must be identified and eliminated.

7.2.4 Controller Head Away and Pilot Head Down Time.

The change from an auditory to visual presentation of messages to controllers and aircrew members could have an effect on their ability to attend to their primary tasks. Controllers and pilots typically continue scanning their display while transmitting messages using voice communication, allowing them to gather

information about their environment. With ADL, controllers and aircrews may have to focus their attention on the display presentations of the ADL menu as well as ADL messages they may have received. This could reduce the amount of time controller or aircrew will be able to scan/monitor their PVD's/displays.

Conversely, data input to FMS's and Flight Data Entries (FDE's) would be reduced, thereby providing controllers and aircrews additional time for viewing their primary displays. The influence of ADL communication on controller head away and pilot head down time needs to be evaluated and quantified.

The information sources in the current environment, the necessity of the information, and the consequences of the reduced party line need to be isolated. Means to provide the aircrew with information, including graphical representation of the airspace, should also be investigated. Procedures and communication policies should be developed that provide the aircrew with an appropriate level of situational awareness enabling them to successfully fulfill their duties. ADL interfaces should be optimized to reduce the workload associated with data message transmission and reception.

7.3 HUMAN/COMPUTER INTERFACE REQUIREMENTS.

Most display interface issues could be considered solely from either the ATC or flight deck perspective. Typical interface design issues would address whether a specific displayed message is legible and understandable. The human interface requirements become an human factors ADL integration issue when hardware systems with varying capabilities and limitations are operated in the same environment. This can be seen in the differences in display formats between the air and ground systems and differences between display formats within the air and ground systems. As the NAS is gradually upgraded and as advanced technology aircraft become more prevalent, controllers and aircrew members may have to contend with various implementations of ADL within one area or flight. Table 3 identifies some sample ADL integration research questions which need to be addressed.

7.3.1 Operational Status Indication.

When evaluating the operational status of a communication system, both the transmitter and the receiver should be considered. With voice communication, the operational status of the receiver is easily assessable. The receiver will receive all messages on its frequency that are transmitted from within its operating range. Previous communication traffic within an aircraft generally confirms the receiver's operational status. The operational status of the transmitter is determined by the transmission of a message and the receipt of a response.

39

The operational status of the ADL system must be readily apparent to the user. Additionally, the ADL user may find it beneficial to know the transport medium for the ADL message.

TABLE 3.   SAMPLE ADL INTEGRATION RESEARCH QUESTIONS - HUMAN/COMPUTER INTERFACE REQUIREMENTS

How will controllers or aircrews know the operational status of the ADL system with regard to their own system and systems they intend to receive messages?

For the ADL system with multiple message transmission paths and different corresponding message response delays, how will operators know the expected message response times?

Will the information displayed to the controller or aircrew provide information equivalent to that available through voice communication including that available through party line?

7.3.2   System Phraseology Dictionary.

The development of the aviation industry has generated the development of many unique terms and phrases that are fully understood by controllers and the aircrew. The use of the terms and phrases are taught to controllers and pilots beginning in their earliest training continuing through to their recurrent training. The definitions of the terms and acronyms have been documented in FAA Order 7110.65, flight operations manuals, as well as other operational documents. The terms and phrases have all been developed for use on the voice communication system which allows a descriptive prose format.

The terms and prose used for ADL messages must be examined to ensure that they will be understood and correctly interpreted. The examinations should investigate the use of abbreviations, acronyms, or graphical presentations. Some of the information transmitted via ADL may be better and more quickly understood when displayed as acronyms, abbreviations, or graphically. Just as phraseology has been developed for use in voice communication, a similar dictionary of unique terms, abbreviations, acronyms, and graphical syntax needs to be developed for ADL communication. In the development of the phraseology dictionary, the terms must not conflict with those used in voice communication and the

standardization of the terms should eliminate any possible misinterpretation. Visually similar words, for example, should be eliminated for ADL just as phonetically similar words have been eliminated in the voice environment.

8. RELATED DOCUMENTATION.

Aviation System Capital Investment Plan, Federal Aviation Administration, December 1990.

Braven, Wim den, Design and Evaluation of an Advanced Air-Ground Data-Link System for Air Traffic Control, NASA Technical Memorandum 103899, January 1992.

Controller Evaluation of Initial Air Traffic Control Services: Mini Study 1, Volumes I and II, DOT/FAA/CT-88/25, September 1988.

Controller Evaluation of Initial Air Traffic Control Services: Mini Study 2, Volumes I and II, DOT/FAA/CT-89/14, March 1989.

Controller Evaluation of Initial Air Traffic Control Services: Mini Study 3, DOT/FAA/CT-91/11, June 1991.

Controller Evaluation of Initial Data Link Terminal Air Traffic Control Services, DOT/FAA/CT-90/29, January 1991.

Controller Evaluation of Initial Data Link Terminal Air Traffic Control Services: Mini Study 2, Volumes 1 and 2, DOT/FAA/CT-92/2.

Controller Evaluation of Initial Data Link Terminal Air Traffic Control Services: Mini Study 3, DOT/FAA/CT-92/18, October 1992.

Functional Baseline Specification for ATC Data Link Service Implementation in the Host Computer System, DOT/FAA/CT-91/12, June 1991.

Human Engineering Issues for Data Link Systems, SAE ARD50027, May 31, 1991.

Kerns, Karol, Data link Communication Between Controllers and Pilots: A Review and Synthesis of the Simulation Literature, MP-90W00027, The MITRE Corporation, July 1990.

Knox, C. E. and C. H. Scanlon, Flight Tests with a Data Link Used for Air Traffic Control Information Exchange, NASA Technical Paper 3135, September 1991.

Kuhl, F. S. and D. L. Berry, Automatic Terminal Information Service (ATIS) via Data Link: Evaluation of a Controller's Workstation, MTR-89W00240, The MITRE Corporation, November 1989.

<u>Operational Evaluation of Initial Air Traffic Control Services</u>, Volumes I and II, DOT/FAA/CT-90/1, February 1990.

<u>Proceedings of the Third International Aeronautical Telecommunications Symposium on Data Link Integration</u>, May 20-23, 1991.

<u>Proposed Research Agenda for Data Link</u> (intended for inclusion in the ATC/Flight Deck Integration Section of the National Plan for Aviation Human Factors), Air Transport Association, January 24, 1992.

<u>Review of the FAA Research, Engineering and Development Program</u>, R&D Review Panel of the FAA Research, Engineering and Development Advisory Committee, November 1991.

<u>The National Plan for Aviation Human Factors</u>, Federal Aviation Administration, December 1990.

APPENDIX A

ATC ENVIRONMENTS

ATC ENVIRONMENTS

The fundamental objective of air traffic control (ATC) is separation of aircraft from each other, from the ground, and from ground-located obstructions. ATC is affected through collaborative, cooperative compliance with the rules, regulations, and procedures that govern ATC by pilots and controllers.

The ATC system is designed around the concept that airspace should be horizontally and vertically partitioned to permit controllers to function independently within clearly defined boundaries. Airspace jurisdiction for the purpose of providing ATC services is assigned to Air Route Traffic Control Centers (ARTCC's), Terminal Radar Approach Controls (TRACON's), and Airport Traffic Control Towers (ATCT's).

Domestically, ARTCC's separate Instrumental Flight Rules (IFR) aircraft operating in en route airspace, i.e., in the route structure that connects major terminal areas. ARTCC's also provide separation services to IFR aircraft operating in international oceanic airspace.

TRACON's provide approach and departure control services at major terminal areas to IFR aircraft leaving and entering en route airspace. At some locations, TRACON's provide similar services to Visual Flight Rules (VFR) aircraft.

ATCT's provide airport traffic control services to IFR and VFR aircraft operating within the Airport Traffic Area (ATA) and on the movement area of the associated airport.

A two-phase consolidation project initiated in 1988 will collocate ARTCC and TRACON functions into a new facility type known as an Area Control Facility (ACF). Phase I, scheduled for completion in 1998, is directed towards accomplishing transition of the ARTCC functions into the new facilities and redesigning the current airspace to encompass geographically larger, more user-efficient airspace alignments. Except for several very complex locations, Phase II will relocate existing TRACON's to the new ARTCC sites to form the ACF's.

APPENDIX B

FLIGHT PHASES

FLIGHT PHASES

For the purposes of this paper, flight phases are considered in context of the communications interactions between controllers and aircrew members that are necessary to ensure flight safety. These include transfer of information regarding aircraft separation, environmental conditions, and operational conditions that are essential to achieving safe, orderly, and expeditious traffic flow.

Radio Technical Commission for Aeronautics (RTCA) SC-169 WG-1 paper of March 5, 1992 identifies five flight phases as appropriate to defining the ADL message set. These are:

1. Predeparture: Interactions which occur prior to pushback.

2. Departure: Interactions which occur from pushback through takeoff to initial climb.

3. Cruise (radar): Interactions which occur from initial climb, through cruise and initial descent to the terminal area, to arrival in the terminal area with radar coverage provided throughout.

4. Cruise (non-radar): Interactions which occur from initial climb, through cruise and initial descent to the terminal area, to arrival in the terminal area. Radar coverage is not provided.

5. Arrival: Interactions which occur from arrival in the terminal area through approach, landing, and taxiing until reaching the gate.

APPENDIX C

ADL SERVICE TYPES
(CLASSES)

ADL SERVICE TYPES
(CLASSES)

For the purposes of this paper, ADL Services are considered in context of the type or class of messages exchanged by controllers and aircrew members to ensure flight safety. As shown in appendix A, to date, 117 candidate ADL Services have been identified by Radio Technical Commission for Aeronautics (RTCA) SC-169 WG-1.

RTCA SC-169 WG-1 paper of March 5, 1992, identifies six ADL Service types (or classes) as appropriate to defining the ADL message set. For completeness, a seventh has been included in this paper. The latter was added following review of FAA Order No. 7110.65, <u>Air Traffic Control</u>. These are:

1. Clearance: An authorization by air traffic control (ATC), for the purpose of preventing collision between known aircraft, for an aircraft to proceed under specified traffic conditions within controlled airspace; e.g., "Cleared I-L-S Runway Two Three Left Approach."

2. Instruction. Directive issued by ATC for the purpose of requiring a pilot to take specific actions; e.g., "Turn Left Heading Two Five Zero."

3. Advisory: Advice and information provided to assist controllers and aircrew members in the safe conduct of flight and aircraft movement. Advisory information is intelligence or a non-binding recommendation that may influence a decision or course of conduct on the part of the recipient: e.g., "Traffic 12 o'clock, 5 Miles, Opposite Direction, Altitude Unknown."

4. Report: Intelligence forwarded by an aircrew member to inform a controller that a condition expressed in a Clearance, Instruction, or Request has been achieved; e.g., a report informing ATC that the aircraft has passed a mandatory reporting point, has passed though flight level two seven zero in response to an Instruction to "report passing flight level two seven zero," etc.

5. Request: The act or instance of asking for something that may have an effect on the safe conduct of the flight; e.g., a request by an aircrew member to change altitude or route of flight; a request by a controller to provide a Pilot Report (PIREP).

6. Emergency: Intelligence forwarded by an aircrew member to inform a controller that a situation critical to continued flight safety has occurred.

7. Acknowledgement: Intelligence forwarded by either an aircrew member or controller that informs the other of knowledge of or intent to comply with a Clearance, Instruction, Advisory Information, Request, or Emergency message; e.g., ROGER, WILCO, AFFIRMATIVE, NEGATIVE, etc.

APPENDIX D

CANDIDATE ADL SERVICES

CANDIDATE ADL SERVICES

Service Name	Environment
ADS Periodic Report	Oceanic
Predeparture Clearance	Terminal
ADS Event Report Contract Establishment	Oceanic
ADS Periodic Report Contract Establishment	Oceanic
Technical Acknowledgement	Utilities
Error	Utilities
Facility in Control	Utilities
ADS Event Report	Oceanic
Transfer of Communication	All
Oceanic Clearance	Oceanic
Terminal Information	Terminal
In-Flight Emergency	All
Initial Contact	All
Altitude Assignment	All
Windshear Advisory Service	Terminal
Flight Plan Amendment Request	All
Time-of-Arrival Metering Goal	All
Communications Backup - Uplink	All
Route Amendment	All
Hazardous Weather Advisory	All
Departure ATIS	Terminal
Arrival ATIS	Terminal
Communications Backup - Downlink	All
Flight Crew Acknowledgement	Utilities
Altimeter Setting	All
Cruise Flight Level Assignment/Confirmation	All
Requested Flight Level Amendment	All
Route Amendment Request	All
Altitude Assignment with Restrictions	All
Request Altitude	All
ADS Single Report Request	All
Air-to-Air ADL Message Routing	All
Flow Management Advisory	All
Top-of-Descent Preference	En Route
Emergency Landing Vectors	All
Heading	All
Controller Acknowledgement	Utilities
Speed Change	All
Speed Request	All
ATC Approach Instructions	Terminal